Journal of Clinical Anesthesia and Pain Medicine

Research Article

A Comprehensive Curriculum of The History of Regional Anesthesia

This article was published in the following Scient Open Access Journal:
Journal of Clinical Anesthesia and Pain Medicine
Received August 30, 2019; **Accepted** September 12, 2019; **Published** September 18, 2019

Gustavo Angaramo[1], James Savage, David Arcella and Manisha S. Desai[1]*
Department of Anesthesiology and Perioperative Medicine, University of Massachusetts Medical School, Worcester, Massachusetts.
[1]Associate Professor of Anesthesiology

Abstract

The study of the past with regards to medical history has been an underemphasized component of the medical school curriculum for several reasons.

These have included the lack of direct or immediate clinical impact, the emergence of new disciplines such as medical ethics, expansion of the existing knowledge base, as well as a lack of research grants and funding. The curriculum in graduate medical education struggles to cope with the explosion of new information related to basic and applied sciences. The elimination of questions related to history in certifying examinations could be considered a fatal blow. This study explored the teaching of history of regional anesthesia (HORA) and proposes a curriculum for such education.

A formal curriculum has not been described in published literature, even the latest guidelines for fellowship training in regional anesthesiology and acute pain medicine published by ASRA in 2015 did not include a curriculum to teach HORA. We propose a curriculum related to a variety of topics that would provide useful information and enrich the educational experience of trainees. It is suggested that this briefly formatted review of HORA could be used as a starting point for teaching and research to place major events of this specialty in an historical context.

Introduction

Anesthesiology is one of the few major medical specialties where discoveries are clearly documented, by the introduction of general anesthesia, and local anesthesia (1,2). The last century has witnessed many developments in the practice of regional anesthesia. What began as a simple method of numbing body parts of the body during surgery has expanded to creating a neural blockade during the perioperative period, either as the sole anesthetic or in combination with general anesthesia. Local anesthetic agents are also increasingly being used in the treatment of chronic pain syndromes. Techniques have evolved from topical application and local infiltration to selective blockade of nerves and plexuses, neuraxial blocks, and the use of ultrasonography to identify neural structures. The purpose of this review is to offer a comprehensive curriculum in HORA (history of regional anesthesia) that could be implemented in training programs.

During a brief online survey conducted regarding the teaching of regional anesthesia in acute pain programs across the country we realized that much needed to be done in that matter.

Some of the barriers identified were lack of trained faculty in the topic, time constrains and most of all the absence of a curriculum to teach HORA. Even the latest guidelines for fellowship training in regional anesthesiology and acute pain medicine published by ASRA in 2015 did not include a curriculum to teach HORA.

Discussion and Proposed HORA Curriculum

This review of the history of regional anesthesia puts forward the following topics as recommendations to be included in the core curriculum for the teaching of HORA: the emergence of ASRA; local anesthetic agents; spinal and epidural anesthesia; brachial plexus block; ultrasonography and the recognition that regional anesthesia reduces morbidity and shorter recovery room stays when compared with general anesthesia in ambulatory surgery.

The origin of American Society of Regional Anesthesia and Pain Medicine (ASRA)

***Corresponding Author:** Manisha Desai, Department of Anesthesiology, UMass Memorial Health Care, 55 Lake Avenue North, Worcester, MA 01655, USA. Tel: 5088563266.

The original ASRA was founded in 1923. It was created to honor Gaston Labat, who has been called the "father" of regional anesthesia and pain medicine in the United States. Labat was a French surgeon and came to America with Mayo Clinic founder Charles Mayo. Labat worked in several hospitals in the U.S. and created a course in regional anesthesia through New York University at Bellevue Hospital. The original ASRA grew out of this work with a focus on the development of local, regional, and spinal anesthesia.

In 1930, Philip Woodbridge presented at an ASRA meeting on the use of therapeutic blocks for chronic pain, which signified a shift in focus to also include pain management in the Society's purview. The association was no longer focused solely on surgical anesthesia, with pain management becoming increasingly emphasized in papers and meetings [3].

Despite numerous advances in regional anesthesia and pain medicine throughout the 1930s, ASRA as an organization began to lose steam by the end of the decade. Meetings were held less frequently, and fewer members were paying their dues. In 1940, the group was dissolved, and members were invited to join the American Society of Anesthesiology, which had been established early in the 20th century.

In 1973 Alon Winnie had a vision of an organization that would be devoted to teaching regional anesthesia. He shared his vision with Harold Carron, Jordan Katz, Donald Bridenbaugh, and P. Prithvi Raj, who reestablished the society in 1975 [4]. Interestingly, the reinvented ASRA originally focused on regional anesthesia but later added pain medicine in the 1990s.

At the time of the society's first meeting on March 18, 1978, the society had more than 300 members. Today it has more than 6500 physician and scientist members and the journal *Regional Anesthesia and Pain Medicine*, is read by over 9000 subscribers internationally.

Today, ASRA is one of the largest subspecialty medical societies in anesthesiology. Change is constant in the field of regional anesthesia and pain medicine as new discoveries are made, changes occur in healthcare administration and insurance, and demographic shifts occur in the patient population. Although many organizations and companies provide offerings to address the needs of individuals working with these challenges, ASRA remains committed to a focus on the highest quality of evidence-based education and research for physicians. This history of ASRA is relevant to today's anesthesiologist so we don't forget the heritage of the past to make certain that regional anesthesia is always available to the patients for whom we care.

Local Anesthetics:

Cocaine: Extracts from the coca plant have been consumed by natives of the Andes region in South America for over 5000 years [3,4]. The active ingredient was separated from the leaves using lime, and used as a stimulant , to decrease air hunger, and to increase endurance. The Incas were the first to observe local anesthetic properties of saliva rich with coca extract. Centuries later, modern chemical processes allowed the extraction, purification, and identification of cocaine. Richard Willstatter [1872-1942] elucidated the structure of plant alkaloids such as atropine and cocaine as part of his doctoral thesis, and later also explored the structure of chlorophyll. For his many contributions to the understanding of plant chemistry,he was awarded the Nobel Prize in Chemistry in 1915 [5,6]. Cocaine's most notable advocate at that time was Sigmund Freud [1856-1939], the famous psychoanalyst, who believed it could be used to cure depression, as well as addiction to morphine or alcohol. He self-experimented with cocaine and described many of its properties but failed to notice its local anesthetic properties [7,8]. That distinction went to Freud's colleague, a rising ophthalmologist Carl Koller [1857- 1944], who observed the tongue-numbing properties of the drug and his team continued with self-experimentation feeling no pain as they touched their own eyes with needles. In 1884 his work debuted at the German Ophthalmological Society Conference in Heidelberg and the international medical community quickly learned about the local anesthetic properties of cocaine [9].

As with the discovery of general anesthesia, controversy arose about the individual[s] who deserved credit for the discovery of the local anesthetic properties of cocaine. Two other 'practitioners', Vassily von Anrep [1852-1927] and Theodor Aschenbrandt claimed to have discovered these properties before Koller's 1884 presentation, but pressure from the medical community in Vienna caused them to reliquish their claims and acknowledge Koller's contribution [10,11]. Later, other physicians used cocaine to obtain analgesia during surgery. William Halsted [1852-1922] used cocaine for a mandibular nerve block during dental surgery [12] and also for a brachial plexus block [13], while August Bier [1861-1949] used it intrathecally as an anesthetic [14]. Self-experimentation resulted in many physicians, including Freud and Halsted, becoming dependent on drugs such as morphine and cocaine. Procaine, synthesized in 1905, replaced cocaine due to its efficacy and longer lasting properties when combined with adrenaline [15]. Even more important, procaine did not possess the addictive property of cocaine. Rarely used these days as a local anesthetic, mostly secluded to ENT [ear, nose, and throat] procedures, the story of the cocaine illustrates how a gateway drug laid the foundation for local anesthetic techniques and a search for improved agents.

Lidocaine: In 1929 two chemists; Hans von Euler [1873-1964] and Sir Arthur Harden [1865-1940] were awarded the Nobel Prize for their work on fermentation. Von Euler then focused his efforts on developing barley strains that were resistant to loss of agricultural output to insects. He isolated a new pesticide called gramin. Von Euler and Holger Erdtman attempted to synthesize gramin but ended up synthesizing the incorrect isomer isogramin. When placed on the tongue, iso-gramin resulted in a temporarily loss of sensation.

In von Euler's laboratory in 1935, Holger Erdtman [1902-1989] and Nils Löfgren [1913-1967] synthesized , different anilides with tongue numbing properties and published their results in 1937[16]. Although none of the agents appeared to be superior to procaine, Löfgren continued to work on these compounds until 1942 when his student Bengt Lundqvist [1922- 1953] convinced him that these drugs ought to be tested by injection rather than producing numbness of the tongue. After conducting a series of clinical experiments, they found that compound LL30 showed great promise as a local anesthetic [17].

Compound LL30 was tested on mice at the Karolinska Institute [Stockholm, Sweden]and found to have greater efficacy, longer duration of action and a less toxic profile than procaine. On July 15, 1943 Löfgren and Lundqvist applied for and obtained a

patent to protect their intellectual property rights. They licensed the product for a two-week trial and were disappointed when the medical and pharmaceutical community showed little interest in their drug. After considering several offers, they transferred ownership of the patent to Astra Pharmaceuticals [Sweden] on November 22, 1943 for 15,000 Swedish Crowns and 4% of all sales for 17 years. Rebranded and tested, Astra marketed the drug in early 1948 as Xylocaine.

Löfgren finished his doctorate in 1948 and published his thesis, "Studies on local anesthetics: Xylocaine: a new synthetic drug" [18]. He stayed on as a professor of organic chemistry at the University of Stockholm where he was precluded from winning research grants as a result of his financial success with compound LL30. Lundqvist sustained a skull fracture after a fall down a flight of stairs. He died from cerebral hemorrhage at the age of 30.

Chloroprocaine: When chloroprocaine was introduced to the market in 1952, lidocaine had already been used for epidural anesthesia as the first amino-amide anesthetic. Lidocaine was less likely to produce allergic reactions than the amino ester-anesthetics [19]. In comparison to chloroprocaine, lidocaine provided a longer duration of action and was cleared less quickly from the body. Chemically similar to procaine, 2-Chloroprocaine became popular because of its rapid onset of action and metabolism by plasma esterases. It had virtually no effect on maternal-fetal physiology and was used extensively for pain relief during labor and delivery [20].

Numerous reports in the 1980s describing long term and even permanent neurological deficits due to local anesthetic agents sent a shockwave through the practice of regional analgesia [21]. Half a dozen cases reported prolonged transient neurological sequelae [TNS] and suggested that the cause might be accidental intrathecal infiltration during epidural catheter placement [22]. Reports of more cases involving accidental intrathecal injection with resulting permanent neurological sequelae, in some cases causing sexual dysfunction [23], forced the manufacturer to find ways to deal with these issues by altering the composition of the preservatives used in the manufacturing process. In 1987, Astra removed preservatives and marketed a UV light protected vial. Nonetheless, fear of causing potentially permanent neurologic complications lead the Food and Drug Administration [FDA] to prohibit the use of preservative containing chloroprocaine for lumbar and caudal epidural blocks.

Several hypotheses were put forward to explain these adverse effects. The high dose and volume of the local anesthetic were blamed initially. However, hundreds of deliberate spinal injections with the same doses had not produced adverse results [24]. Several of the early reports involved medications without preservatives, nonetheless, other studies suggested that preservatives such as methylparaben, ethylene diamine tetra acetate [EDTA], and sodium bisulfite were to blame [25]. It was known that these additives significantly prolonged the shelf life of the drug and inhibited bacterial growth. Studies on animal models and in-vitro neuronal stem cells showed proliferative and architectural changes when exposed to 2-chloroprocaine with and without sodium bisulfite [26].

A study in animals by Taniguchi showed that intrathecal injection of sodium bisulfite caused less neurological dysfunction compared to chloroprocaine alone, bringing into play more confusion about the identity of thecausative agent; was it the local anesthetic or the preservative? [27]. Despite this study, FDA regulations restrict Astra, the current manufacturer of chloroprocaine [Nesacaine-MPF] to market the drug without bisulfite. In Europe, epidural administration of chloroprocaine with preservatives is permitted and surveillance studies have not revealed evidence of neurological deficit. Thirty years later, there is a lack of clear evidence pointing to any single mechanism responsible for neurotoxicity associated with the use of epidural chloroprocaine.

Bupivacaine and its toxicity: Numerous new amino amide local anesthetics were synthesized between 1898 and 1972 including nirvaquine, procaine, chloroprocaine, cinchocaine, lidocaine, mepivacaine, prilocaine, efocaine, articaine, etidocaine, and bupivacaine [28]. Attempts were made to decrease toxicity, control onset and duration of action, and decrease the likelihood of drug dependence.

It had already been established that the central nervous system was more susceptible to local anesthetics when compared to the cardiovascular system [29]. One pivotal case by Prentiss illustrated the danger of etidocaine during caudal anesthesia; causing convulsions and cardiac arrest in a health young male [30]. More examples of the toxic effects of local anesthetics emerged as Albright added five other case reports linked to lipid-soluble anesthetics and the dangerous effects on the cardiovascular system and the central nervous system [31]. As is the case with most established practices, resistance erupted against such causative claims.

Bupivacaine, synthesized in 1957, is of special interest because of its long duration of action and history of clinical application. Several case reports highlighted the potential toxicity of 0.75% bupivacaine. This resulted in much investigative work to understand mechanisms of its toxicity. In theory, the toxicity was thought to be related to the cardiac sodium channels [32]. The anesthetic was further characterized as "fast-in, slow-out" due to its prolonged blockade and a potent depressant of the maximum upstroke velocity of cardiac muscle action potential. Awareness of this unique behavior of bupivacaine led to the design of enantiomers, such as levo-bupivacaine and ropivacaine, each having their own physiological properties.

These drugs, even in their present state, were still incredibly valuable to multimodal pain techniques and their use was "rescued" by an astute observation on a patient with carnitine-deficiency. It was Weinberg who showed that the accumulation of fatty acids within the mitochondria enhanced the toxicity of bupivacaine [33]. Therefore, infusion of a lipid would emulsify the anesthetic and reduce its activity when toxicity was encountered. This was proven by his series of experiments on dogs and rats which showed the rescue effect of lipid emulsion therapy on the cardiotoxic effects of bupivacaine.

Several years later, Rosenblatt showed its utility during cardiac arrest where electrical defibrillation was successful only after lipid infusion [34]. The mechanism is believed to be lipophyllic binding which isolates the drug in a 'lipid sink".

Understanding the history behind the creation of these drugs allow a better appreciation in our daily practice.

The Brachial Plexus: Halstead applied the theory of local anesthesia to peripheral nerves for surgery of the upper extremity, defending its use in the scientific community and encouraging others to discover its possibilities. A pupil of Halstead, Harvey Cushing, published a report concerning its efficacy with regard to avoiding complications of shock, comparing two surgeries on the shoulder, one without cocainization and the other with cocaine applied proximal to the division of nerve trunks [36].

The first percutaneous supraclavicular block was performed in 1911 by German surgeon Diedrich Kulenkampff [1880–1967] [37]. Later, Georg Hirschel [1875–1963] described a percutaneous approach to the brachial plexus from the axilla [38]. Livingston compiled a review of the achievements of the time in 1927, stating, 'On the basis of strict comparison, it cannot be said that the untoward effects from brachial plexus block are of more severity than those of inhalation narcosis. Furthermore, even in the experimental era, complications and disagreeable by-effects occurred with only a small percentage of patients, while the average patient receives the brachial plexus anesthesia without unfavorable symptoms' [39]. Thus he opened the door for regional anesthesia as a less harmful technique when compared with general anesthesia.

In 1928, Kulenkampff and Persky published a report about a thousand blocks without apparent major complications. The technique applied to the patient was described in that they would be in the sitting position or in the supine position with a pillow behind the shoulders. The needle was inserted above the midpoint of the clavicle where the pulse of the subclavian artery could be felt and it was directed medially toward the second or third thoracic spinous process [40]. By the late 1940s, clinical experience with brachial plexus block in both peacetime and wartime surgery was extensive, and new approaches to this technique began to emerge [41].

In 1946, F. Paul Ansbro was the first to describe a continuous brachial plexus block technique. This was done by a needle being secured in the supraclavicular fossa with tubing connected to a syringe through which incremental doses of local anesthetic could be injected [42]. The subclavian perivascular block was first described by Winnie and Collins in 1964 [43]. This approach became popular due to its lower risk of pneumothorax compared to the traditional Kulenkampff approach.

The infraclavicular approach was first developed by Raj in 1973 [44]. In 1977, Selander described a technique for continuous brachial plexus block using an intravenous catheter secured in the axilla [45]. The development of a more practical and portable nerve stimulator [NS] in 1962, led to increased use among practitioners. Reports questioning the safety of the paresthesia technique such as those by Selander in 1979 encouraged clinicians to explore other approaches during the last decade of the 20th century. In 1989, another modality was introduced into clinical practice. Ting and Sivagnanatnam utilized ultrasound to confirm needle placement and observe local anesthetic spread during axillary nerve blocks [46].

'Today, upper extremity plexus blocks have an obvious place as a sole anesthetic technique or as a powerful complement to general anesthesia, reducing the need for analgesics and hypnotics intraoperatively, and providing effective postoperative pain relief'.

Bier block [Intravenous Regional Anesthesia]: In August 1908 Karl August Bier, Professor of Surgery in Berlin, revealed a new method of producing analgesia of a limb which he named 'vein anesthesia' [47].

Bier first presented this new method of intravenous regional anesthesia [IVRA] at the 37th Congress of the German Surgical Society on 22 April 1908, only 10 years after other significant communication on spinal anesthesia [48]. The method consisted of occluding the circulation in a segment of the arm with two tourniquets and injecting a dilute local anesthetic through a venous cut-down in the isolated segment. Bier used procaine, the first safe injectable local anesthetic that had been synthesized by Einhorn in 1900 [15].

After initial enthusiasm, the technique fell into obscurity for >50 years. In 1963, Holmes reintroduced Bier block with the novel use of lidocaine [49].

Today, intravenous regional anesthesia of the upper limb remains popular because it is reliable, cost effective, safe, and simple to administer.

Spinal and epidural anesthesia: The advent of spinal anesthesia cannot be fully accredited to the arrival of cocaine into the medical field. It served many purposes including ophthalmology, treatment of depression by Sigmund Freud [50], and even being added to Coca-Cola in 1886 [51]. The credit should go to the clinicians who first attempted to apply this drug to the spinal column. Procedures approximating the spinal column were regarded by the scientific and medical community as high risks with permanent paralysis being the result. However, these pioneers went ahead and tested their hypotheses, changing the field of anesthesiology and obstetrics.

Karl Gustav Bier [52], is credited with the first use of operative spinal anesthesia on the lower limbs although James Leonard Corning was the first to use cocaine in the spinal column in 1885 [53], several years earlier than Bier [48]. A native of Stamford, CT, his family fled to Germany when he was a young boy. The influence of German and French physicians influenced Corning's curiosity. Upon returning to the United States, he began his practice of Neurology in New York City, attending the Roosevelt Hospital. Corning had been in the surgical auditorium in 1884 when William Halstead and Richard Hall successfully demonstrated one of their peripheral nerve blocks [54]. A year later he first demonstrated spinal anesthesia by injecting 2 ml of 3% cocaine into the T11/T12 interspinous space in a gentleman suffering with "spinal weakness" and "seminal incontinence". Minutes later the patient experienced impaired sensitivity in the legs, genitalia and lumbar region as well as post-dural puncture headache. The theory published by him stated that the mechanism of anesthesia was through the infusion of cocaine into the tissues surrounding the spinal column and by diffusion into the venae spinosae. Because his procedure did not describe fully penetrating the dura, he was not credited with being responsible for the first spinal block. Bier's block did this in 1899, entering the spinal column fully and injecting less of the cocaine solution to provide the anesthetic effects. He never applied his findings in the operating room, but

he may have used this technique to relieve forms of paresthesia in his own patients.

Despite the utility of spinal anesthesia, the preference of spinal anesthesia for nerve blockade and lower extremity surgery was secondary to general anesthesia because of the feared neurologic sequelae.

One case report detailed paraplegia with two previously healthy middle aged males [55,56].

In 1956, a study from the Hospital of the University of Pennsylvania by Dripps and Vandam showed that a long term follow up of over 10,000 patients who received spinal anesthesia resulted in no long term neurologic sequelae [57].These findings improved the public image of spinal blocks and their use in the operating room and in pain clinics [58,59].

Caudal blocks and epidurals came into use in children much later. In the early years these blocks were performed by surgeons, but as other doctors began to give anesthetics the specialty of anesthesia evolved, and these practitioners gradually took over this role. On August 16, 1898, August Bier tried to induce spinal anesthesia with cocaine. All of his six patients, including two children – the first to have spinals – had postoperative vomiting and headache, and Bier felt that the technique had little advantage over general anesthesia. In 1909–1910,H. Tyrell Gray, superintendent at the Hospital for Sick Children at Great Ormond Street, London, published three detailed papers each based on more than 100 cases of spinal anesthesia in children. They occupied 14 ½ pages in the Lancet [60].Gray's patients were not anesthetized but were comforted by a nurse who knew them. Some were even allowed to have cake! Six retched and 21 vomited during the anesthetic. The incidence of vomiting postoperatively was very low, only 2%. In three patients, spinal anesthesia failed, and general anesthesia was instituted. Gray concluded that the benefits to the patient were as follows: absolute anesthesia, no surgical shock, the analgesia was localized to the area of the block, and postoperative vomiting was minimal. The advantages for the surgeon were as follows: good operating conditions, easy access to the abdomen, the bowel was constricted, surgery could be completed quickly, and the anesthetic could be administered by the surgeon. Postoperatively, there was less pain, and feeding could be started sooner. These papers illustrate how much was known about spinal anesthesia in children, more than 100 years ago.

Caudal blocks now play a major role in pediatric anesthesia, but they were first reported for cystoscopies in children by Meredith Campbell when she presented a paper to the American Society of Regional Anesthesia in 1933 [61]. By 1950, Harry Curwen in Durban, South Africa, was using caudal blocks in neonates, he recognized the potential advantages, especially for the occasional pediatric anesthetists or doctors working in the rural areas [61]. Schulte Steinberg, who had trained with Philip Bromage in Montreal, working in the county hospital in Starnberg [Germany] used caudal anesthesia and undertook studies on the dermatomal levels reached in children, with different volumes of local anesthetic with added X-ray contrast. Schulte Steinberg went on a sabbatical in Durban, where caudal anesthesia was used commonly. He studied caudal catheters in piglets and human cadavers and found it was possible to thread them easily to the thorax in small children [62]. Bosenberg then applied the method clinically in newborns with biliary atresia and subsequently found that by using continuous infusions via caudal catheter, the need for postoperative ventilation in babies with oesophageal atresia and other surgical conditions was reduced. His work demonstrated that epidural analgesia can be provided for neonates undergoing major surgery with a low risk of complication [63]. Further advantages include the reduced need for muscle relaxants, opioids and postoperative ventilatory support.

Spinal and other local anesthetic techniques in children had ups and downs in popularity likely related to improvements in general anesthesia.

Ultrasound Guidance: A technology originally used to detect submarines during warfare, ultrasound found initial medical use in fetal monitoring and identification of gallstones, but it would take several decades before it was adopted to identify nerves.

In 1978 La Grange developed a unique approach of delivering local anesthesia to the brachial plexus using Doppler ultrasonography [58].

This type of ultrasonography only provided unidimensional images and they reported no neurological sequelae or pneumothorax. It did not become popular due to the prohibitive cost of this technology. In 1989 Ting described ultrasonographic visualization of local anesthetic spread during brachial plexus block. Instead of Doppler, they use a B-mode ultrasound device that provided two-dimensional visualization. Their conclusions emphasized improved visualization of the brachial plexus but did not comment on improved efficacy and safety.

In 1994, Kapral [64], reported a significant decrease in the amount of anesthetic needed to produce clinical analgesia using ultrasound guidance during brachial plexus block. Moreover, the technique was associated with fewer complications, while patients reported less discomfort. The stage was set for a revolution in techniques used to identify neural structures that could be blocked with local anesthetic agents. Improvements in anesthetic techniques can bring about major changes in surgical approaches. Ultrasound guided regional anesthetics have enabled patients to emerge from minimally invasive day-surgery with almost no pain or side effects.

Regional vs General Anesthesia: any improvement in outcomes?: As in all fields of medicine, there has been an explosive growth in clinical research related to regional anesthesia. In 1987, Yeager [59] and colleagues showed a dramatically reduced mortality in high-risk patients who received regional anesthesia. In 2000, Rodgers and colleagues published an extensive meta-analysis showing a reduction in postoperative mortality and morbidity with neuraxial anesthesia with the subsequent recommendation of more widespread use of this technique [60].

Spinal anesthesia is the preferred anesthetic method for sub-umbilical surgery, particularly in elderly patients and parturients. Parker and colleagues [61], investigated in a Cochrane meta-analysis 22 clinical trials involving 2567 patients where neuraxial [mainly spinal] anesthesia was compared with general anesthesia for hip fracture surgery. The authors found a reduced risk for postoperative deep venous thrombosis [30% compared with 47%] and acute postoperative confusion [9.4% compared

with 19.2%] in patients treated with neuraxial [mainly spinal] anesthesia compared with general anesthesia. There was no evidence for reduced perioperative mortality. Peripheral nerve blocks and local anesthesia have very few cardiovascular or pulmonary side-effects. Complications do occur, and peripheral nerve block must be performed with adequate safety precautions by anesthetists with appropriate experience. In experienced hands, it seems likely that peripheral nerve block would be safer than general anesthesia due primarily to the avoidance of airway management. However, evidence to prove this assumption will never be available due to the low numbers of severe anesthesia-related complications. At the same time opioid consumption can be decreased or even avoided, in consequence, opioid-related side-effects can be reduced when perineural block is performed. Whether regional anesthesia influences outcome after surgery is a controversial topic, in skilled hands, various regional anesthetic techniques are powerful tools providing almost perfect perioperative pain therapy. Using an optimal balance between appropriate techniques, application of advanced equipment, and optimal doses of drugs, regional anesthesia plays an important role in perioperative medicine.

Conclusions

Regional anesthesia has a fascinating history, with events following the introduction of general anesthesia by a half-century. As with general anesthesia, techniques and drugs have evolved over time, and currently many patients receive concurrent care under both techniques. During the late 19th and early 20th century regional anesthesia was the preferred technique because of complications associated with general anesthesia, and a shortage of anesthesia providers. Ensuing decades showed the use of regional anesthetics decreasing as general anesthesia became safer. However, recent advances in techniques, drugs and applications have led to a resurgence in the use of regional anesthesia. We believe historical aspects of regional anesthesia can and should be taught as part of the educational curriculum.

References

1. Sim P. The heritage of anesthesia. Park Ridge, Illinois: *Wood Library-Museum of Anesthesiology*; 2012.
2. Eger EI, Saidman LJ, Westhorpe RN. The wondrous story of anesthesi.New York: *Springer*. 2014.
3. Karch S. A Brief History of Cocaine: From Inca Monarchs to Cali Cartels: 500 years of Cocaine Dealing. Bocan Raton: *CRC Press*; 2006.
4. Karch SB. A history of cocaine: The mystery of coca java and the kew plant. *J R Soc Med.* 2003 ; 96[11]:568–569.
5. Willstatter RM, Stoll A. From my life: The memoirs of Richard Willstatter. New York: Benjamin; 1965.
6. Willstatter R, Wolfes D, Mader H. Synthese des naturlichen cocains. *Justus Liebigs Ann Chem*. 1923;434:111-139.
7. Markel H. An anatomy of addiction: Sigmund Freud, William Halsted, and the miracle drug cocaine. New York: *Pantheon Books*; 2011.
8. Freud S. Ueber coca. *Zentralblatt Ges Ther*. 1884;2:289-314.
9. Koller C. Preliminary report on local anesthesia of the eye [translated report of the original presentation at the 1884 meeting of the German Ophthalmological Society, at Heidelberg]. *Arch Ophthalmol*.1934;12[4]:473-474.
10. von Anrep NB. Ueber die physiologischen wirkungen des cocains. *Pfluger's Arch Ges Physiol*. 1880;21[1]:38-77.
11. Aschenbrandt T. Die physiologische wirkung und die bedeutung des cocain. Muriat auf den menschlichen organismus. *Dtsch Med Wochenschr*. 1883;50:730-732.
12. Raymond EH. Hydrochlorate of cocaine as a local anesthetic in dental surgery. *Dental Cosmos*. 1885;27:207-226.
13. Halsted WS. Practical comments on the use and abuse of cocaine; suggested by its invariably successful employment in more than a thousand minor surgical operations. *New York Medical Journal*. 1885;42:294-295.
14. Redman M. Cocaine: What is the Crack? A Brief History of the Use of Cocaine as an Anesthetic. *Anesthesiology and Pain Medicine*. 2011;1[2]: 95-97.
15. Einhorn A. Ueber neue arzneimittel. *Liebig's Ann Chemie*. 1900;311:26-77.
16. Erdtman H, Lofgren N. Uber eine neue gruppe von lokalanasthetisch wirksamen verbingdungen. *Svensk Kemisk Tidskrift*. 1937;49:163-174.
17. Lofgren N, Lundqvist B. Studies on local anaesthetics II. *Svensk Kemisk Tidskrift*. 1946;58:206-217.
18. Lofgren N. Studies on local anesthetics. Xylocaine, a new synthetic drug. Stockholm: Chemistry, *Stockholms Hogskola*; 1948.
19. Eggleston ST, Lush LW. Understanding allergic reactions to local anesthetics. *Annals of Pharmacotherapy*. 1996;30[7-8]:851-857.
20. Bonica JJ. Obstetric analgesia and anesthesia: A manual for medical students, physicians in training, midwives, nurses and other health personnel. Amsterdam: *World Federation of Societies of Anesthesiologists*; 1980.
21. Reisner LS HB, Plumer MH. Persistent neurologic deficit and adhesive arachnoiditis following intrathecal 2-chloroprocaine injection. *Anesthesia Analgesia*.1980;59[60] :452-454.
22. Ravindran RS BV, Tasch MD, Gupta CD, Luerssen TG. Prolonged neural blockade following regional anesthesia with 2-chloroprocaine. *Anesthesia Analgesia*.1980; 59[6]:447-451.
23. Moore D, Spierdik, J., van Kleef, JD., Coleman, RL., Love, GF. Chloroprocaine neurotoxicity: four additional cases. *Anesthesia Analgesia*. 1982; 61[2]:155-159.
24. Gissen A. The Chloroprocaine Controversy: I. A Hypothesis to Explain the Neural Complications of Chloroprocaine. *Regional Anesthesia*. 1984;124-134.
25. Gissen A. The Chloroprocaine Controversy: II. Is Chloroprocaine Neurotoxic? *Regional Anesthesia*. 1984;9:135-145.
26. Baker M. Cocaine or Sulfite Toxicity? *Anesthesiology*. 2004:1247.
27. Taniguchi M. Sodium Bisulfite: Scapegoat for Chloroprocaine Neurotoxicity? *Anesthesiology*. 2004;85-91.
28. Ruetsch Y, Boni, T, Borgeat, A. From cocaine to ropivacaine: the history of local anesthetic drugs. *Curr Top Med Chem*. 2001;175-182.
29. Di Gregorio G, Neal JM, Rosenquist RW, Weinberg GL. Clinical presentation of local anesthetic systemic toxicity: A review of published cases, 1979 to 2009. *Reg Anesth Pain Med*. 2010;35:181-187.
30. Prentiss JE. Cardiac arrest following caudal anesthesia. *Anesthesiology*. 1979;50:51-53.
31. Albright GA. Cardiac arrest following regional anesthesia with etidocaine or bupivacaine. *Anesthesiology*. 1979;51:285-287.
32. Clarkson CH, LM. Mechanism for bupivacaine depression of cardiac conduction: fast block of sodium channels during the action potential with slow recovery from block during diastole. *Anesthesiology*. 1985;396-405.
33. Weinberg G, Laurito, CE. Geldner, P. Pygon, BH. Burton, BK. Malignant ventricular dysrhythmias in a patient with isovaleric acidemia receiving general and local anesthesia for suction lipectomy. *Journal of Clinical Anesthesiology*. 1997;668-670.
34. Rosenblatt MA, Abel M, Fischer GW, Itzkovich CJ, Eisenkraft JB. Successful use of a 20% lipid emulsion to resuscitate a patient after a presumed bupivacaine-related cardiac arrest. *Anesthesiology*. 2006;105:217-218.
35. Litz RJ, Popp M, Stehr SN, Koch T. Successful resuscitation of a patient with ropivacaine-induced asystole after axillary plexus block using lipid infusion. *Anaesthesia*. 2006;61:800-801.

36. Cushing H. On the Avoidance of Shock in Major Amputations by Cocainization of Large Nerve-Trunks Preliminary to their Division. With Observations on Blood-Pressure Changes in Surgical Cases. *Annals of Surgery*. 1902;321-345.

37. Kulenkampff D. Zur anästhesierung des plexus brachialis [in German] [On anesthesia of the brachial plexus]. *Zentralblatt fur Chirurgie*. 1911;38:1337-1340.

38. Hirschel G. Die anasthesierung des plexus brachialis fuer die operationen an der oberen extremitat [in German] [Anesthesia of the brachial plexus for operations on the upper extremity]. *Munchener Medizinische Wochenschrift*. 1911;58:1555-1556.

39. Livingston E. Brachial Plexus Block: Its Clinical Application. *JAMA*. 1927:1465-1468.

40. Kulenkampff D, Persky MA. Brachial plexus anaesthesia: Its indications, technique, and dangers. *Annals of Surgery*. 1928;87:883-891.

41. de Pablo JS, Diez-Mallo J. Experience with three thousand cases of brachial plexus block: Its dangers: Report of a fatal case. *Ann Surg*. 1948;128:956-964.

42. Ansbro FP. A method of continuous brachial plexus block. *American Journal of Surgery*. 1946;71:716-722.

43. Winnie AP, Collins VJ. The subclavian perivascular technique of brachial plexus anesthesia. *Anesthesiology*. 1964;25:353-363.

44. Raj PP, Montgomery SJ, Nettles D, Jenkins MT. Infraclavicular brachial plexus block. *Anesth Analg*. 1973;52:897-904.

45. Selander D. Catheter technique in axillary plexus block: Presentation of a new method. *Acta Anaesthesiol Scand*. 1977;21:324-329.

46. Ting PL, Sivagnanaratnam AM. Ultrasonographic study of the spread of local anaesthetic during axillary brachial plexus block. *Br J Anaesth*. 1989;63:326-329.

47. Bier A. Ueber einen neuen Weg Localanasthesie an den Gliedmassen zu erzeugen [On a new technique to induce local anesthesia in extremities]. *Arch Klin Chir* 1908;86:1007-1016.

48. Bier A. Versuche uber Cocainisirung des Ruckenmarkes [Experiments on the cocainization of the spinal cord]. *Dtsch Z Chir*. 1899;51:361-369.

49. Holmes C. The history and development of intravenous regional anesthesia. . *Acta Anaesthesiologica Scandinavica*. 1969:11-18.

50. Freud S. Cocaine papers. New York: *Stonehill*; 1975.

51. Boville Luca de Tena B. The cocaine war: In context: Drugs and politics. New York: *Algora Publishing*; 2004.

52. Hinnerk FWW. The centennial of spinal anesthesia. *Anesthesiology*. 1998;89:500-506.

53. Corning J. Spinal anaesthesia and local medication of the cord. *NY Med J*. 1885;42:483-485.

54. Looseley A. Corning and cocaine: *the advent*. 2001.

55. Cope RW. The Woolley and Roe case: Woolley and Roe versus Ministry of Health and Others. *Anaesthesia*. 1954;9:249-270.

56. Maltby JR, Hutter CDD, Clayton KC. The Woolley and Roe case. *Br J Anaesth*. 2000;84:121-126.

57. Vandam LD, Dripps RD. Long-term follow-up of patients who received 10,098 spinal anesthetics: Syndrome of decreased intracranial pressure [headache and ocular and auditory difficulties]. *Journal of the American Medical Association*. 1956;161:586-591.

58. La Grange P, Foster P, Pretorius L. Application of the Doppler ultrasound blood flow detector in supraclavicular brachial plexus block. *Br j Anaesth*. 1978;50:965-967.

59. Yaeger MP, Glass DD, Neff RK, Brinck-Johnsen T. Epidural anesthesia and analgesia in high risk surgical patients. *Anesthesiology*. 1987;66:729-736.

60. Rodgers A, Walker N, Schug S, et al. Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. *British Medical Journal*. 2000;321:1493-1493.

61. Parker MJ, Handoll HH, Griffiths R. Anaesthesia for hip fracture surgery in adults Surgery in adults. *Cochrane Database Syst Rev*. 2001;4:CD000521.